ANALYSIS OF WESTERN SPRUCE BUDWORM APPLICATION COSTS DURING 1987 AND 1988 SUPPRESSION PROJECTS

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EXECUTIVE SUMMARY

A statistical analysis of aerial spraying (application) costs was conducted for spray units from the 1987 and 1988 budworm suppression projects in Oregon and Washington. Restricted least squares was used to estimate two statistical cost models formulated to explain variations in per acre application costs contained in initial contract bids.

Application cost is the largest component of total treatment cost. Results reported here provide a basis to better predict future application costs on individual spray units and explore ways of controlling costs.

This study finds that contract performance provisions, projected time for completing a unit's treatment, application volume, and regional suppression program size contribute significantly to explaining the level of per acre application costs. For example, the 500,000 acre increase in spray program size between 1987 and 1988 is estimated to have raised per acre application costs by nearly $5.

Estimated (as opposed to actual) hourly contractor performance is also a major contributor to the cost of application. A 25 percent increase in available daily spray time or spray days reduces costs between $1.67 and $2.67 depending on the value of other explanatory variables.

Reducing the total length of time contractors must make equipment and labor available to a spray project will lower costs. The study results suggest that a cost-savings of up to $0.55 per acre can be achieved for each day of reduction in project duration.

The results provide a basis for improving estimates of per acre application costs for individual analysis units. Cost estimates can be made more sensitive to the most important variables influencing application costs. A new estimation procedure will allow a more accurate cost-benefit ranking of public investment opportunities for budworm suppression.

From a cost control vantage, expenditures can be minimized by keeping a regional suppression project under 300,000 acres in size. The Forest Service should assume additional risk of not completing treatment of all acres in a given current year. This might be accomplished through lower hourly performance requirements, which strongly influences the number of application resources contractors must maintain at the site.

The total volume of material applied per acre should be kept to a minimum. Spray units and bid items should be configured to reduce the length of time a contractor must commit resources to a spray effort.

Wide advertisement of requests for proposals will foster high levels of competition. Whenever feasible, solicitations should be sequenced so that closure of an existing solicitation is achieved before advertising the next. This will maximize the level of competition on the earliest requests. It will also give an indication of how application costs will rise as greater market pressure is placed on remaining regional applicator resources.

Relative to the 1988 project, these control measures, if reasonable to effect, have the potential to realize cost savings of about $6 per acre, and possibly as high as $10.

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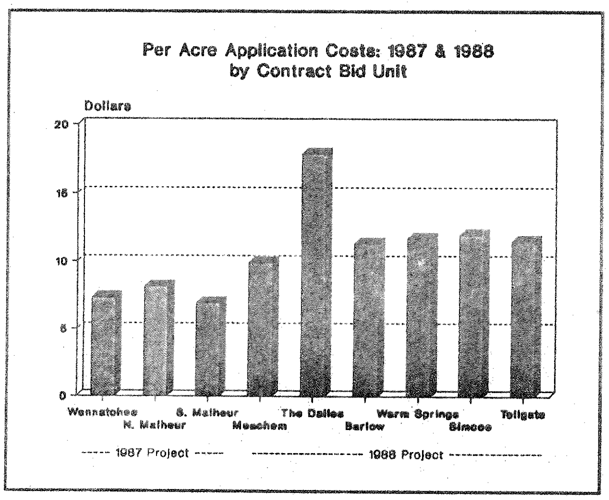
INTRODUCTION

Over the last 2 years in the Pacific Northwest Region, the total cost of treating an acre of forest land infested by western spruce budworm, *Choristoneura occidentalis* Freeman, has increased dramatically. Much of the increase can be ascribed to contract bids to supply aircraft for applying insecticide. As shown in Figure 1, the average cost of applying insecticide to an acre of forest land nearly doubled between 1987 and 1988.

Figure 1. Per acre application costs of western spruce budworm in the Pacific Northwest: 1987-1988.



Application cost also showed more variation between individual treatment units in 1988. Costs ranged from $9.90 to $17.90. In 1987, only $1.25 separated the highest and lowest per acre cost of application.

In 1988, a sharp disparity was experienced between projected and actual treatment cost. While actual costs were expected to be somewhat higher than initially projected, because of an increase in project size, the large difference was not expected. Projections underestimated costs by as much as 35 percent for certain treatment units.

A focus on treatment cost is important because of the role it plays in identifying and ranking economic opportunities for budworm control. Total project size and the setting of treatment priorities are greatly influenced by accuracy of treatment cost estimates. The less accurate are estimates, the greater is the chance of under or over investing in budworm treatment. Inaccurate cost estimates can misrepresent the relative economic attractiveness of prospective treatment areas. The budgeting process also requires good cost estimates.

In the past, average per acre costs from the most recent suppression project were used as the basis for making treatment cost projections. This cost projection technique performed adequately prior to 1988, although 1987 showed some symptoms. The poor 1988 performance prompts a need to find a more accurate method for estimating treatment cost. A new method should also permit making cost estimates for individual treatment units.

OBJECTIVE

The motivation for this evaluation is to improve projections of budworm treatment costs. One way of accomplishing this task is to develop new techniques for projecting individual components of treatment cost. Insecticide application has been the major and most variable of the components. Insecticide application can comprise as much as 50 percent of total treatment cost.

This evaluation identified two objectives:

- To build an improved model for projecting the application cost component of contract bids; and

- to improve understanding of factors influencing application costs.

With regard to the first objective, the intent is to build a projection model which accounts for the influence of 1) the characteristics of treatment units; 2) contract provisions; and 3) general market conditions.

The purpose of the second objective is to identify which and understand how various factors influence application costs. This will provide a basis to suggest measures for controlling application costs.

FACTORS INFLUENCING COSTS

Factors affecting the cost of aerial spraying have not commanded a great deal of examination. To isolate factors potentially impacting aerial application costs, this study must combine applicable tenets of economic and financial theory with recent experience acquired during major application projects.

Contract bids for aerially applying insecticide are influenced by a variety of considerations. Proposed as most important are local applicator market conditions, type and vintage of application equipment, site specific conditions affecting application, contract specifications, logistics, and pest development dynamics.

Application contractors operate in a dynamic and competitive market. Under these conditions, contractors will submit bids that reflect anticipated operational costs and yield rates of return competitive with other opportunities for using their resources. These bids will also be adjusted to reflect any risk or uncertainty envisioned inherent in a project.

More specifically, the number of acres that can be sprayed in a given period of time is a critical consideration in determining application costs. Full utilization of equipment is important. Spraying entire and continuous days until project completion would produce minimum cost to the contractor. Achieving this ideal would also lead to the lowest contract bids. Any departure from this ideal increases bids.

During budworm control, weather conditions and insect population development can create quite variable opportunities for spraying. This variability affects the level of equipment utilization, which, in turn, is an important consideration in determining what to charge per acre for the use of aerial application equipment. With the expectation of less time to spray each day or fewer application days comes the prospect of lower equipment utilization. This necessitates higher levels of per acre compensation (contract bids) to justify provision of application resources, and visa versa.

In addition, the magnitude of potential peak application needs influences the number of resources a contractor must commit to a project. Anything that increases the area treated per unit of time by an aircraft promotes greater equipment and labor utilization and, thus, reduces costs. This cost reduction will be reflected in lower bids by prospective application contractors.

Several other factors will influence application costs. The volume of fluid applied per acre determines, in large part, the number of acres that can be treated per hour. If high volume application rates are required, more unproductive time is needed to ferry between the loading and application sites; hence, per acre application costs rise. Also, the more remote an area, the longer are ferrying times and, thus, the greater are costs.

The size of treatment units could also influence per acre costs. If there exists a large investment in fixed overhead, spreading the associated costs over a larger area will reduce per acre cost of application. Whether or not this phenomenon exists is a empirical question.

Some spray units offer the opportunity for use of fixed rather than rotary-wing aircraft. The consensus of opinion is that, where terrain permits, fixed-wing aircraft can apply insecticide at a lower cost than rotary-wing aircraft. The feasibility of using fixed-wing aircraft does not automatically convey a cost advantage over rotary application. Logistical considerations, such as accessibility to airports, may negate any pure engineering cost advantages. Hence, the direction and magnitude of effect is an empirical question.

Looking at general market conditions, the larger the total project becomes the greater the pressure applied on the supply side of the market. Under competitive market conditions, greater demand for applicator services will drive up the price of these services as less cost efficient services are drawn into the bidding process.

The amount of financial and other risk assumed or shared by contractors and the government will also influence bids. How strictly contracts are administered, in terms of interpretation of nonperformance and associated level of penalties, will impact per acre application costs.

From year to year and project to project, a number of other factors will influence application cost. For example, major changes in contract specifications certainly will affect bids. Or, changes in general regional and national economic conditions will alter pressures in the market for applicators' services.

A high level of competition is a desirable feature of the bidding process. This mitigates upward pressure on bids induced by limited local applicator services. Wider and more visible advertisement for proposals will foster greater interregional competition.

METHODS

Data

This analysis is conducted with information from the 1987 and 1988 western spruce budworm suppression projects in the Pacific Northwest Region. Data were drawn from the Solicitation for Bids and the initial bids submitted by contractors receiving contract awards. Table 1 displays the sample data series for nine observations--three from 1987 and six from 1988.

The data displayed in Table 1 may differ from those contained in other sources. Many changes occur over the course of contract negotiation and project implementation. For this reason, the data series contained in initial contract bids, upon which this evaluation is conducted, may differ from those compiled after the suppression project.

The contract specifications for 1987 and 1988 differ in several respects. Two differences are known to have had a direct and major effect on the cost of application contained in the bids. The 1987 solicitation required contractors to provide insecticide and mixing; 1988 did not. In 1988 the contracts included boundary marking.

Comparability of data from the two years was achieved by means of two adjustments. First, to achieve a series containing just application costs, both insecticide and mixing costs were removed from the 1987 data. Best judgment suggested a $4 per acre reduction in 1987 application costs. The second adjustment entailed removing boundary marking costs from the 1988 cost data. Hence, the application cost data series for both years contains neither pesticide materials, mixing, nor boundary marking costs.

Table 1. Database for analysis of western spruce budworm suppression project application costs--Pacific Northwest Region, 1987-88.

	Contract Bid Units								
	1987			1988					
Data Series	Wenatchee	North Malheur	South Malheur	Meachem	The Dalles	Barlow	Warm Springs	Simcoe*	Tollgate
Application costs (dollars per acre)	7.34	8.18	6.93	9.90	17.89	11.34	11.69	12.00	11.49
Project duration (consecutive days)	25.00	30.00	30.00	25.00	28.00	27.00	25.00	25.00	25.00
Spray days (number of days)	10.00	14.00	14.00	10.00	7.50	12.00	11.50	12.00	12.00
Average unit size (1000s of acres)	44.0	115.0	100.0	56.0	73.0	91.5	65.0	110.0	56.5
Application volume (ounces per acre)	96.0	96.0	96.0	43.0	64.0	44.3	64.0	64.0	64.0
Fixed-wing spraying (fraction of acres)	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.8	0.3
Year of treatment (0=1987; 1=1988)	0	0	0	1	1	1	1	1	1
Performance needed (acres sprayed per hour)	2200	4200	3700	2800	5214	3813	3180	4700	2354
Resource effort (performance/ave. unit size)	50.00	36.52	37.00	50.00	71.42	41.67	48.92	42.73	41.66

Table 1 displays the adjusted cost series for the nine bid items. Shown also are eight other data series used by the analysis. All variables are described as follows:

Dependent variable:

APCOST - per acre bid cost for insecticide application.

Explanatory variables:

RES_EFFORT - an index of application capability needed per 1000 acres, or 1 divided by the number of hours projected to be available to complete treatment.

DURATION - projected length of time or duration over which application will be needed.

VOLUME -ounces of material applied per acre.

FIXED - proportion of area estimated to be amenable to fixed-wing application.

YEAR - a shift variable to detect the influence of changes in total project size and other factors between 1987 and 1988 projects (0=1987 and 1=1988).

AVACRES - average number of acres within units of each bid item.

Models

Two models are formulated to analyze variations in per acre insecticide application costs. The cost models, as shown in Table 2, are specified in terms of explanatory variables outlined in the discussions provided earlier. Models I and II differ in only one respect. Model I tests the hypothesis that per acre application costs are lowered by increasing the proportion of a unit's area amenable to treatment by fixed-wing aircraft.

Table 2. Application cost models.

VARIABLE	MODEL I	MODEL II
RES_EFFORT	*	*
DURATION	*	*
VOLUME	*	*
FIXED	*	
YEAR	*	*
AVACRES	*	*

Analytical Methods

Restricted least squares is selected as the statistical tool to estimate the cost models. Restricted least squares is a mixed estimation technique that permits using prior information about the value of one or more of a cost model's coefficients [Kementa 1971, Koutsoyiannis 1977]. Using prior knowledge in the estimation process results in better or more statistically efficient estimates for the remaining coefficients. That is, estimates will tend to be closer to the true value of the coefficient.

The prior information of importance to this study is that related to how different volumes of material applied per acre affects application costs. Cost data from 1983 and 1984 budworm environmental analyses shed light on this subject. These data suggest that applying an additional ounce of material per acre changes application costs between $0.035 and $0.055 per acre in 1987 dollars.

For estimation purposes, it is assumed that a 1 ounce increase in application volume will increase per acre costs by $0.05. The coefficient for the volume explanatory variable is constrained to be $0.05 during the estimation process.

A preliminary analysis was conducted to determine the appropriate mathematical forms of the cost relationships. Results for linear specification of the models are presented here. However, exploratory analysis suggests that nonlinear specifications are worthy of further consideration in future analyses.

Table 3. Estimated models of per acre application costs.

VARIABLE	MODEL I	MODEL II
CONSTANT	-21.626* (-3.08)	-16.640* (-2.81)
RES_EFFORT	0.200* (5.08)	0.191* (4.71)
DURATION	0.565* (1.75)	0.330 (1.23)
VOLUME	0.050 (----)	0.050 (----)
FIXED	2.242 (1.19)	
YEAR	5.987* (6.24)	6.361* (6.69)
AVACRES	0.000 (0.03)	0.024 (1.166)
R^2	.975	.963
SEE	.856	.898

*Values in parentheses are t-values. An asterisk indicates statistical significance for a one-tail test at the 10 percent level.

All models were estimated using the econometric package Regression Analysis of Time Series [VAR Econometrics 1987]. The procedure RESTRICT was employed to estimate the models subject to the linear restriction on the VOLUME coefficient.

RESULTS

Sorting out the individual influences of explanatory variables was difficult because of the small sample size, lack of variation in all variables, and high intercorrelation among the explanatory variables. Table 3 summarizes the statistical results. Appendix A contains more detailed statistical results.

Both cost models resulted in remarkably high explanatory power: more than suggested by first order correlation coefficients. Coefficients of determination (R^2) exceeded .96 for both models, indicating the models' abilities to account for most of the variation in costs.

The statistical results confirm expectations on how the explanatory variables affect application costs. The directions of influence of the explanatory variables are as expected, recognizing that, for some variables, the direction of influence was essentially an empirical question.

Several of the coefficients are not statistically different from zero at the 10 or less significance level in one or both models. These are FIXED, DURATION and AVACRES. In all models, the size of an individual spray unit (AVACRES) was not found to significantly influence application costs.

A statistical test was also conducted to determine whether using prior knowledge to fix the coefficient on the VOLUME variable was supported by the sample data. Recall that, on the basis of previous spray projects, a 1 ounce change in application volume was assumed to change per acre application costs by $0.05. Neither model could reject this hypothesis at the 10 percent significance level.

The good performance in explaining variation should not leave the reader with the impression that the models will be good predictors. Model I took top honors for lowest standard error of estimate--.856--one measure of prediction performance. This estimate implies there that predictions for a treatment unit exhibiting average attributes will be within $1.70 of the true per acre cost about 95 percent of the time. Prediction error will increase as units depart from average values of the predictor variables.

Model I

Specific interpretation of the results first centers on Model I. Increasing the expected length of time required to complete spraying (DURATION) raises per acres costs by $0.57 for each additional day. With a standard error of .31 (Appendix A), there is a lot of variability associated with the estimate of this coefficient.

Expected resource effort (RES_EFFORT) has a positive influence on costs. Recall that this variable is an index of the number application resources per 1000 acres recommended to be available for spraying. When there is an expectation of fewer days in which to treat, contractors must have more resources on the spray site to assure completion of the job.

The statistical results indicate that RES_EFFORT is extremely important in determining per acre application costs. In the sample RES_EFFORT, ranges from 37 on the Malheur units to 71 on The Dalles unit. This disparity in resource effort is estimated to have caused nearly a $7 difference in per acre application costs.

Based on previous experience, the cost associated with changes in the volume of material applied per acre (VOLUME) was fixed at $0.05 per ounce. For example, changing from 43 to 96 ounces per acre could add in excess of $2.65 to application costs. The statistical results support the $0.05 assertion.

One of the anomalies of the study is the impact of the proportion of a bid item amenable to treatment by fixed-wing aircraft. Fixed-wing aircraft is generally believed to be a less expensive means of applying pesticides than rotary-wing aircraft. The study results do not support this proposition. If there is an influence, the sample data suggests that it is positive. Even at that, a ten percentage point change is estimated to increase per acres costs only about $0.22.

The theoretical discussion hypothesized larger units to show economies of scale that would reduce per acre application costs. This hypothesis could not be supported in the context of Model I. AVACRES showed no significant impact on application costs. However, it should be noted there may have been insufficient variation in the size of units to isolate this influence. The negative constant hints at two things in this regard: 1) the model specification should be nonlinear, and 2) the data set was generated from units in the size range exhibiting diseconomies.

Economic theory also suggests that changes in the size of a total regional spray program will impact the market for applicators' services. As discussed earlier, larger projects will exert more pressure on limited regional supplies. Under such market conditions, a normal competitive response is to bid up the price of applicator services and, hence, application costs.

An attempt was made to measure the impact on the general level of application costs of the large increase in project size between 1987 and 1988. This presents a most difficult problem as the data set contains only two observations on different market conditions--1987 and 1988. It is possible to statistically account for a change in average application cost between 1987 and 1988. However, a number of other factors may also contribute to a change: different contract specifications, subregional changes in project location, or generally different economic conditions.

To account for this influence, a shift variable YEAR was entered in both cost models. Looking at the YEAR shift variable in Model I, one can observe an increase in average application costs of almost $6 per acre between 1987 and 1988. It is probably safe to assume that the nearly 500,000 acres increase in project size accounted for most of the change. However, because there is no way to control for several other factors that also changed between the 1987 and 1988 projects, a more definitive assessment of the magnitude of impact caused by the increase in project size is not possible.

Model II

This model was estimated for the purpose of making projections of application costs for use in the next budworm environmental analysis. Model II is similar to Model I except for excluding as an explanatory variable the amount of area amenable to treatment by fixed-wing aircraft (FIXED).

When there is an opportunity to use fixed-wing aircraft, experience suggests that treatment units are configured or consolidated to larger sizes to take advantage of this type application technology. As a result, the data show a high correlation between the AVACRES and FIXED explanatory variables. The strong relationship makes difficult estimating their independent effects on application costs. This can lead to incorrect signs on the estimates (as was suspected in the case of FIXED).

Unit size (AVACRES) is deemed the more important predictor variable of the two. Also, the data series for FIXED is, to some degree, contaminated by inaccuracies. For these reasons, the FIXED variable was dropped from Model II so as to improve the estimate of the AVACRES coefficient.

The results for Model II are very close to those of Model I. One exception is the expected length of the project. It does not have as much influence, raising per acre application costs by only $0.33 per additional day. This variable also loses its statistical significance.

Unit size (AVACRES) performs better as an explanatory variable in this model. But it does not achieve statistical significance. It is retained in the model on theoretical grounds. As stated for Model I, units larger than 50,000 acres may already show some diseconomies of size. The increase in cost per 1000 acres is estimated to be only $0.02 per acre, which is negligible.

DISCUSSION

This study was conducted to achieve two objectives. The first objective was to develop a better technique for predicting per acre cost of applying insecticide to analysis units. The second objective was to enhance understanding of the role of various variables in determining application costs. The statistical results reported here, even though based on a scant nine observations, take a major step toward achieving these objectives.

Improving Cost Projections

Models I and II perform similarly in predicting per acre application costs. The sign of the coefficients are all consistent with the theoretical postulates. Model II is preferred for projecting application costs.

Inclusion of the FIXED variable in the projection model is not deemed appropriate at this time. A feeling among professionals exists that the cost of operating fixed-wing aircraft is lower than rotary aircraft. Even so, the cost advantage of fixed versus rotary-wing can be more than offset by other factors such as the longer ferrying distances often required by fixed-wing aircraft. Inclusion of both the distance to nearest airstrip and the percent of area amenable to fixed-wing treatment would be a better way to model the influence of fixed-wing aircraft use on application cost.

Interestingly, when Model II is estimated without the FIXED variable, its performance does not deteriorate materially. Furthermore, the coefficients of the remaining variables change only slightly. The exception is unit size (AVACRES) which, for reasons stated earlier, is likely to have a strong correlation with the proportion of area amenable to fixed-wing treatment.

To implement Model II as a cost estimation procedure requires having observations on all explanatory variables or information needed to compute these variables. Estimates of treatment days, unit size, performance requirements, daily application hours, project duration, and regional spray program size are needed prior to conducting the economic analysis for a budworm environmental assessment.

Cost Control

Cost control measures must be viewed with caution. While the statistical analysis can suggest areas for cost control, it has not taken into account the potential for creating a loss in benefits. When considering a cost control measure, offsetting losses in benefits must be weighed against the cost-savings.

From the viewpoint of the statistical analysis, several observations can be made on cost control. First, the biggest control measure comes by keeping the size of the total project to a reasonable level. The 500,000-acre plus increase in initial project size between 1987 and 1988 is estimated to have contributed a $6 increase in per acre application costs. Thus, for each 100,000 acre increase above a base level of 300,000, a $1 increase in per acre application costs can be expected.

Another possible method of cost control relates to application volume. As noted earlier, past projects suggest about a $0.05 change in costs per acre per ounce. The cost of the 1988 project would have been much higher with an application rate of 96 ounces per acre rather than the 43 and 64 ounces. A 53 ounce change is predicted to add $2.65 to the ticket or $0.50 for each 10 ounces. Lower application rates would be more a treatment unit. Or, means can be developed to manage risk. This will reduce the level of resource effort perceived by prospective bidders. In either case, the economic payoff to a greater assumption or management of risk by the Forest Service could be substantial.

To keep 1989 application costs to a minimum, the following suggestions can be made on the basis of the results of this statistical analysis:

1. Keep total project acreage under 300,000 acres to minimize market pressures and foster competition. Potential savings is estimated at between $4 and $5 per acre on the assumption that project size accounted for about 75 percent of the shift in average costs between 1987 and 1988. Reversion to contract provisions of 1987 might pick up an additional $1 to $2 application cost savings but could bring other offsetting costs.

2. The Forest Service should assume more risk in not fully achieving acreage targets. There is always next year. Reflecting this increased risk in the estimates affecting hourly performance needs and in more accurate estimates of treatment days and daily spray hours could achieve a substantial savings. The amount of the savings is difficult to determine at this time but might reach to $2 or $3 per acre application costs.

3. Application volumes should be kept as low as feasible. Holding volumes to 43 ounces per acre will keep future costs from rising on this account. Unless volumes are further reduced, there is no anticipated cost saving. However, because of physical and other limitations of application aircraft, there may exist a floor below which no further cost reductions could be achieved by reducing application volume.

4. To every degree possible, treatment areas should be configured in size and geography to minimize the length of time a contractor needs to commit resources to a spray effort. The object is to reduce project duration and performance requirements. This can achieve about $0.50 per acre per day reduction in costs of application.

Other steps to minimize a contractor's average resource effort will likely have similar cost reduction impacts. An example is to allow them to build up equipment and personnel as required instead of implying a need to have a full complement of resources available from beginning to end.

5. Every attempt should be made to foster high levels of competition in the bidding process. Wide advertisement of the requests for proposals will maximize the number of responses. Projects involving large acreages should be advertised as separate bid requests in stages over time.

For example, advertisement of requests for proposals on just the first 100,000 acres of a larger project (or acreage deemed feasible) will produce greater competition and lower bids. This is particularly true if contractors are uncertain that additional acres will be advertised. Proposals for subsequent requests for bids can be evaluated for their economic viability as bid prices begin to rise with the commitment of the region's applicator resources to previous contract proposals.

In total, these actions could be expected to reduce real 1989 application costs over those of 1988 in the neighborhood of $6 to $1 per acre. Of course, this figure will vary unit by unit, depending on site specific attributes, contract provisions, and, most importantly, the size of an annual regional spray program.

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APPENDIX A

STATISTICAL RESULTS

MODEL I

Unrestricted Model

```
DEPENDENT VARIABLE     1      APCOST
OBSERVATIONS               9     DEGREES OF FREEDOM      2
R**2             .98564214     RBAR**2            .94256856
SSR          1.2616149         SEE          .79423388
DURBIN-WATSON  2.29523788
Q(   4)=    3.25861        SIGNIFICANCE LEVEL  .515517
NO.       LABEL      VAR  LAG     COEFFICIENT    STAND. ERROR     T-STATISTIC
***      *******     ***  ***    ************    ************    ************
  1       CONSTANT     0    0   -27.51369        8.125925        -3.385915
  2       RES_EFFORT  15    0    .1838333        .3867732E-01    4.753000
  3       DURATION     2    0    .6758029        .3131640        2.157984
  4       VOLUME       5    0    .9464601E-01    .3668772E-01    2.579773
  5       FIXED        6    0    2.516292        1.767870        1.423347
  6       YEAR         7    0    7.934678        1.831201        4.333046
  7       AVACRES     11    0   -.9364571E-02    .2732553E-01   -.3427042
```

Restricted Model

```
RESTRICT(CREATE) 1
# 4
# 1.0 .05
F(   1 ,    2) =    1.480893         SIGNIFICANCE LEVEL    .3477463


DEPENDENT VARIABLE     1      APCOST
OBSERVATIONS               9     DEGREES OF FREEDOM      3
R**2             .97501091     RBAR**2            .93336243
SSR          2.1957734         SEE          .85552584
DURBIN-WATSON  2.20375066
Q(   4)=    7.16441        SIGNIFICANCE LEVEL  .127451
NO.       LABEL      VAR  LAG     COEFFICIENT    STAND. ERROR     T-STATISTIC
***      *******     ***  ***    ************    ************    ************
  1       CONSTANT     0    0   -21.62631        7.032618        -3.075144
  2       RES_EFFORT  15    0    .1995355        .3927531E-01    5.080430
  3       DURATION     2    0    .5655458        .3229048        1.751432
  4       VOLUME       5    0    .5000000E-01    .5888251E-09    .8491487E+08
  5       FIXED        6    0    2.242206        1.888781        1.187118
  6       YEAR         7    0    5.987480        .9592051        6.242127
  7       AVACRES     11    0    .7863444E-03    .2802931E-01    .2805436E-01
```

Model II

Unrestricted Model

```
DEPENDENT VARIABLE     1      APCOST
OBSERVATIONS               9     DEGREES OF FREEDOM      3
R**2            .97109824       RBAR**2          .92292863
SSR         2.5395774           SEE          .92006836
DURBIN-WATSON  1.90132474
Q(    4)=    3.54536        SIGNIFICANCE LEVEL  .471015
NO.      LABEL      VAR  LAG    COEFFICIENT    STAND. ERROR    T-STATISTIC
***     *******     ***  ***   ************    ************    ************
  1     CONSTANT      0    0  -21.13139        7.850420        -2.691752
  2     RES_EFFORT 15    0    .1769155        .4445001E-01    3.980102
  3     DURATION      2    0    .3995429        .2847019        1.403373
  4     VOLUME        5    0    .8799318E-01   .4215402E-01    2.087421
  5     YEAR          7    0   8.056727        2.119000        3.802136
  6     AVACRES      11    0    .1809968E-01   .2241403E-01    .8075159
```

Restricted Model

```
RESTRICT(CREATE) 1
# 4
# 1.0 .05
F(    1 ,     3) =    .8123316        SIGNIFICANCE LEVEL    .4338615
```

```
DEPENDENT VARIABLE     1      APCOST
OBSERVATIONS               9     DEGREES OF FREEDOM      4
R**2            .96327230       RBAR**2          .92654460
SSR         3.2272370           SEE          .89822561
DURBIN-WATSON  1.59731399
Q(    4)=    .935280        SIGNIFICANCE LEVEL  .919446
NO.      LABEL      VAR  LAG    COEFFICIENT    STAND. ERROR    T-STATISTIC
***     *******     ***  ***   ************    ************    ************
  1     CONSTANT      0    0  -16.64000        5.921977        -2.809872
  2     RES_EFFORT 15    0    .1911501        .4056319E-01    4.712404
  3     DURATION      2    0    .3301976        .2676010        1.233918
  4     VOLUME        5    0    .5000000E-01   .0000000        .0000000
  5     YEAR          7    0   6.360848        .9514032        6.685754
  6     AVACRES      11    0    .2429275E-01   .2082831E-01    1.166333
```